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The Effluent and Water Advisory Committee

Tailor-made to help solve your effluent and water-usage problems

by J. Leicester
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Mr. J. Leicester, Chairman, The Effluent and Water Advisory Committee.

Water-pollution and water-conservation research in the UK is both extensive and diverse, involving a few laboratories working over a very broad field, and many others working only on the effluents peculiar to their sectors of industry. Generally speaking, the water problems encountered by one firm in a given industry will not differ greatly from those confronting all the other firms in the same industry, and the restrictions on effluent discharge will also tend to be common to all. Hence a common approach is called for. The research association catering for the needs of a specific industry will obviously be acutely aware of its industry's problems, and, consequently, when it comes to tackling its water and effluent problems on a co-operative basis, the industry has naturally turned to its RA. As the demand for process water grows, and as further legislation designed to control discharge of pollutants (eg, the Deposit of Poisonous Waste Act 1972) is introduced, the amount of research needing to be carried out will also grow. The RAs role here has been, is, and will be an important one. Many have already built up a unique mass of research data, expertise and experience in this field, and have made their know-how available to their members—**but, in the main, only to their members**—through their information, advisory and consultative services. Water usage, effluent processing and water pollution are, however, nation-wide problems, and many aspects of these problems are shared by different industries. It would therefore seem sensible and valuable to pool the relevant information to which the RAs have access, and make it available to industry—where possible free of charge, but otherwise at a reasonable price. Now, with the formation of the Effluent and Water Advisory Committee, this has been done.

The background

In its report* to the former Minister of Housing and Local Government, the Working Party set up in 1969 to look at the factors involved in sewage disposal identified three dominant influential aspects: sewage as a potential source of disease; sewage as a source of environmental pollution; and the growing demand for water. In the words of the report: 'To the basic sanitary considerations must be added the amenity demands of a more aware society and the apparently insatiable thirst of industry and individuals.' Sewage disposal has long ceased to be a problem from the point of view of disease, but there is increasing concern over its pollutant effects ('People want more than reassurances of safety from disastrous germs—they want clean beaches and clear rivers and shining fish', says the report) and the water wastage associated with sewage. The need to conserve water makes it inevitable that sewage will no longer be disposed of simply as unwanted waste, and the increase in demand will have to be met as far as possible by recirculating water—ie, by using treated sewage effluent. Since industrial and agricultural effluent comprises about half of all public sewage, industry has obvious responsibilities here, and to a great extent it is accepting its responsibilities. Indeed, by 1970—at the time the Working Group was recommending that 'all discharges of trade effluents to public sewers should be subjected to control and liability for charges'—industry had already begun to tackle effluent treatment and water utilisation on a more deliberate basis, and in some sectors the spearhead of this activity was the RAs. The Effluent and Water Advisory Committee was established as the co-ordinating and organising body (under the sponsorship of the Committee of Directors of Research Associations) following the successful outcome of a collaboration between the eight textile research associations aided by grants from the former Ministry of Technology and the Water Resources Board. Its 23 member organisations are listed in the box on page ii. There are 18 research association members, and these were joined on the Committee by the Atomic Energy Research Establishment, the Irish Institute for Industrial Research and Standards, the Department of Trade and Industry and the Department of the Environment (including DoE's Water Pollution Research Laboratory).

The Committee's aims and activities

The stated aims of the Committee are:

(1) to ensure that industrial organisations in need of information and assistance are aware of the help available and are speedily directed to where it can be obtained (the main aspects of interest being: the treatment, purification and

* *Taken for Granted*, Report of the Working Party on Sewage Disposal, 1970; HMSO, 50p.

The Effluent and Water Advisory Committee

Members:

Research Organisations

British Cast Iron Research Association
British Coke Research Association
British Food Manufacturing Industries Research Association
British Glass Industry Research Association
British Launderers' Research Association
British Leather Manufacturers' Research Association
British Non-Ferrous Metals Research Association
Coal Tar Research Association
Corporate Laboratories of the British Steel Corporation
Electrical Research Association
Heating and Ventilating Research Association
Institute for Industrial Research and Standards
Lambeg Industrial Research Association
PIRA Research Association for Paper and Board, Printing and Packaging Industries
Shirley Institute
SIRA Institute
United Kingdom Atomic Energy Authority
Water Research Association
Welwyn Hall Research Association
Wira

Government Departments

Department of the Environment
Department of Trade and Industry

All research-organisation members are willing to advise on industrial water-usage and effluent problems falling within their field of expertise. Some can also undertake design of treatment plant, undertake investigations on a contract basis, and represent a company in negotiations with a pollution-control authority.

The following lists give some idea of the wide range of unit processes and topics on which expertise is available:

Activated sludge
Adsorption
Aeration
Anaerobic digestion
Balancing
Biological filtration
Biological treatment
Centrifugation
Chlorination
Coagulation
Cooling
Disinfection
Dispersal
Desalination
Electro-chemical treatment
Emulsion cracking
Filtration
Flocculation
Flotation
Foam separation
Freeze conditioning
Ion-exchange
Micro-straining
Neutralisation
Nitrification
Oxidation
Oxygen transfer
Reverse osmosis
Sedimentation
Sludge treatment
Tertiary treatment
Algae
Analysis, chemical and biological
Contra-flow processing
Corrosion
Costs
Dispersion studies
Effluent standards
Effluent surveys
Flow tracing
Ground water
Industrial waste waters
Instrumentation
Materials testing
Negotiation with pollution-control authorities
Network analysis and design
Nutrient removal
Operations research
Optical control
Pollution tracing
Recovery and reclamation of materials
Respirometry
Sampling and monitoring
Solid-waste disposal
Testing new chemicals
Toxicity
Treatability
Washing and rinsing
Water conservation
Water quality and usage
Water reclamation
Water supply
Water-mains cleaning and maintenance

re-use of trade effluents; and minimising the amount of primary water required per unit weight of product);

(2) to identify trends affecting industrial effluents and usage of water, and the effects, in this context, of statutory regulations;

(3) to stimulate co-ordination of research work, and help prevent duplication of effort;

(4) to identify and draw attention to areas in which research is required;

(5) to promote specific topics of assistance to particular groups within industry.

How are the aims to be achieved? Beginning at the beginning, the Committee has prepared a register of research in progress at, and of the facilities available from, member organisations, and this register forms the basis of its clearing-house activities. In short, when any firm with a problem or enquiry falling within the Committee's term of reference contacts the Committee for guidance, the index cards will be scanned for an organisation or organisations with the particular experience or expertise required. The problem or enquiry will then be routed to the organisation best able to offer a solution or supply the information. At this stage the Committee's entrepreneurial role ends, and it bows out, leaving organisation and firm to make contact directly. A leaflet on the service will be available in the near future, and a fuller directory of the water-pollution and water-usage expertise available from member organisations will be published as soon as possible.

In addition to this clearing-house service, the Committee is working towards its objective in various other ways. One way is by organising conferences—for example, the Committee is planning a conference on the technical and economical aspects of biodegradeability.

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Typical of the research carried out by members of the Effluent and Water Advisory Committee is that for which the British Leather Manufacturers' Research Association this year received the Queen's Award to Industry. Alkaline sulphides are universally used in the manufacture of leather, as an accelerator in the removal of hair or wool prior to tanning. The Association gained the Award for the development of a process, which, involving a system of oxidation based on catalysed aeration, removes sulphides from trade effluents much more cheaply than alternative methods—and, moreover, without the use of hazardous chemicals and with no offensive by-products. The initial process centred on the application of low-pressure diffused air, but subsequently further improvements in efficiency were achieved through the use of surface aerators. The two versions are now available as alternatives. Treatment systems based on the development are in use in the United Kingdom and overseas, and the process has already found application outside the leather industry. The photograph shows a test rig used by the Association in its laboratory work on diffused aeration.

Holding Crumbling Frescoes together . . .

RAE shows how

In the June issue of New Technology we drew attention to a method of repairing slurry roofs, which had emerged as an offshoot to the Royal Aircraft Establishment's investigations into the effects of vibration on various structures. Below we describe another unusual spin-off from this work—a method of maintaining dilapidated frescoes intact until they can be restored by an expert.

Many very old churches in this country have mural decorations—frescoes or other types of picture produced by applying paint directly to a plaster substrate. Often the murals are as old as the church itself (300 or 400 years old in many cases), and inevitably time and neglect have taken their toll: some have deteriorated to such an extent that the plaster (and with it, of course, the painting) crumbles away at the slightest touch. Gazing at the massive lorries and heavy traffic which are now a feature of even 'country' life, many a custodian of such wall paintings must therefore live in dread that one day vibration will reduce his mural to a pile of plaster dust. Old murals have an antiquarian, if not always an artistic, value, and in this context could be regarded as part of the national heritage—in other words, they are worth saving. Whether they *can* be saved depends on several factors. Most important of all is the question of time. It often takes time to raise the money required for preservation treatment, and there is sure to be a long time lapse before an expert with the knowledge and skill required for fresco restoration can be found and is ready to start work. And time is the very thing which can least be spared—a crucial factor; for, if deterioration is well advanced, what is to prevent the mural collapsing before the rescue operation starts? Well, one method of doing so has been developed by the Royal Aircraft Establishment, Farnborough.

To protect the mural from vibration and shock, the RAE technique had to satisfy two prerequisites. It had to apply only just enough pressure to support the whole of the mural surface and damp any vibration (too much pressure would abrade or otherwise damage the painting, and the task is complicated by the irregularity of the plaster surface and the difficulty of achieving a uniform overall pressure); and it had to ensure that this sensitive support is achieved without excluding air from the surface of the mural (if the plaster were unable to 'breathe', it would 'sweat', causing irreparable damage to the painting). RAE met these requirements by using small very-low-density polystyrene spheroids as the support for the mural. The RAE technique is essentially a stop-gap, designed solely to maintain the *status quo*. It is strictly functional, and protection entails covering, and hence concealing, the mural completely. Within these limits, however, it does its job efficiently and cheaply.

The RAE protects a mural as follows. A ladderlike framework is erected over, but not touching, the mural (see Figure 1). The outer face of the framework is covered with sheets of linen fabric, attached to the wooden members by upholsterers' staples, and the space between the sides of the framework and the wall is blocked with soft foam, backed by a tissue-paper lip seal. The cavity formed by the covered framework and the wall is then filled with the polystyrene spheroids, and finally the gap left open for this purpose at the top is sealed. Nominally $\frac{3}{16}$ in. (5 mm) in diameter and 4-6 lb/ft^3 (64-96 kg/m^3) in density, the spheroids behave in bulk almost like a liquid, flowing from one receptacle to another freely under the action of gravity, and offering no resistance to a hand plunged beneath their surface. The pressure which they apply to the surface of the painting is extremely light, but entirely adequate for support and damping. The linen covering of the framework being loose-woven, and the packing constituents being spheroidal, air is able to penetrate to the surface of the mural, and the plaster therefore continues to 'breathe' while protected. And, since in bulk the spheroids act virtually

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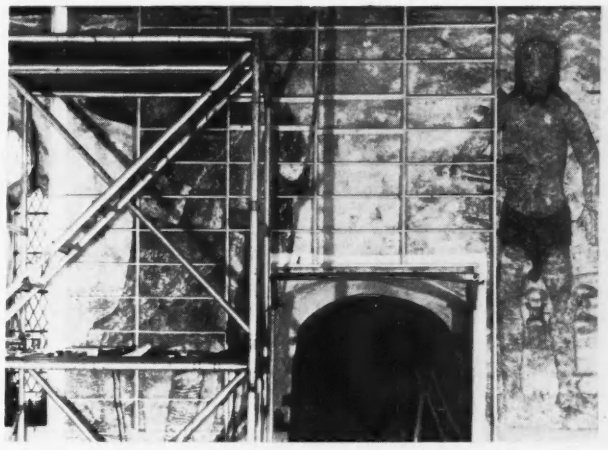


Figure 1. Erecting the wooden framework which, when covered with linen panels, retains the polystyrene spheroids used by RAE in its method of supporting and protecting crumbling murals against vibration.

Figure 2. How well the RAE protective covering fits in with its surroundings can be seen from the above. In this case, colour photographs of the frescoes protected were attached to the covering to give visitors some idea of what the paintings look like.

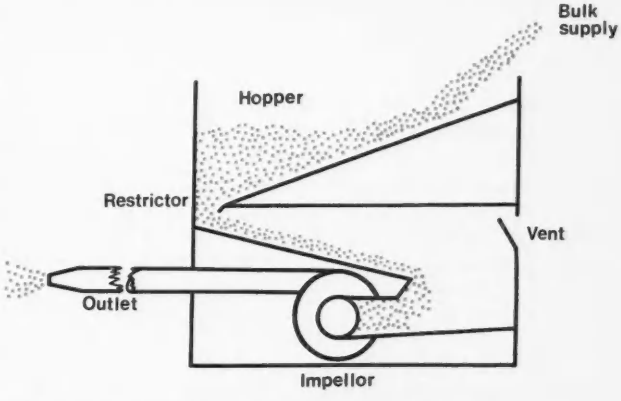


Figure 3. Diagrammatic cross-section of the filling pump.

Teaching without Tears with AVDA

by F. W. Coultas,
Industrial Applications Unit, Royal Radar Establishment

This article gives details of a diagnostic aid which—originally developed to ease the ever-increasing load placed on service technicians by constant innovations in the swiftly changing fields of advanced weapons, electronics and radar—adopts a new approach to system checking and fault diagnosis by the use of a self-contained audio-visual unit based on programmed routines. The equipment is extremely versatile, in that it extends computer control to educational, medical and commercial applications.

Path finding and training

Training has been said to require a stimulus and reward approach. From this point of view it is an aspect of learning which can result from a series of attacks on a problem on a trial-and-error basis, wrong moves or actions being discarded as failures and correct ones being selected and remembered as successes. We therefore have *yes* moves which lead to a desired result, and *no* moves which require further actions to get on to a *yes* path. Hence, in the process of acquiring a complicated skill, there evolves a set sequence of correct steps, derived from the initial rejection of incorrect moves and the gradual elimination of those which do not give the desired result.

This process, then, produces a series of *yes* paths to be followed, and *no* paths to be rejected—branches, as it were, in what can be thought of as a trial-and-error tree. A record of the *yes* paths to follow to achieve a given object may be written down as the actions which would need to be taken with a given set of instruments, but an operator may have to rely on his own skills or knowledge should one of these paths break to a *no*. If his knowledge is insufficiently deep, he may find himself in a situation similar to that faced by the proverbial sorcerer's apprentice, who, having followed the 'manual of spells' to set an action going, did not then have enough skill, or enough information, to halt the process.

The programmed routine

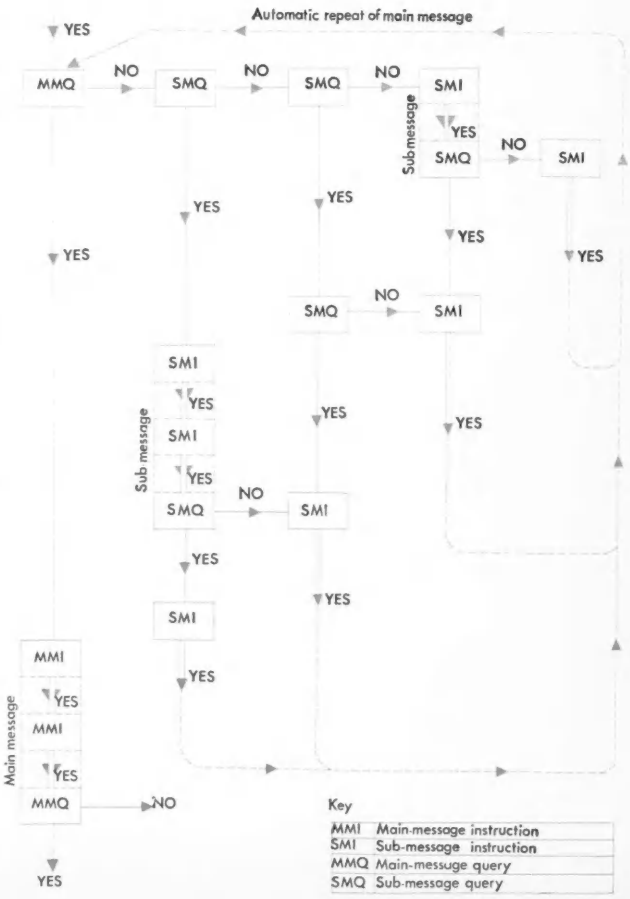
The same reasoning applies to the instructions required for, say, setting up fully operational electronic equipment. For, here again, if unusual situations arise (such as a fault condition), the technician will have to rely on his own skills or, if his skills are insufficient, will have to consult the comprehensive servicing manual supplied with the equipment. Manuals are usually excellent works, but their interpretation needs time and skill, and the time lapse depends upon the individual technician and upon the pressure under which he may be working. And, in any case, unless he has experienced the type of situation confronting him many times before, he may not be able fully to plan the actions which he must take.

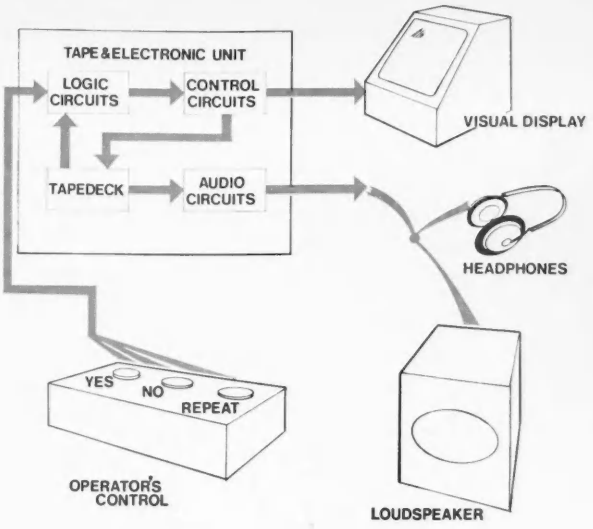
If all the contingencies or unusual situations can be anticipated, the moves required to resolve them can be reasoned out under stress-free conditions; then, when an emergency condition occurs, the correct solution can be 'played back' as a yes/no branching tree—in other words, as a 'programmed routine'. A programmed routine therefore can be presented to an operator or technician in such a way as to relieve him of the responsibility for logical deduction when faced with the need to repair equipment under adverse conditions. It also enables an equipment user to diagnose module faults merely by following a simple recorded routine, and hence enables him to clear the fault with the minimum of delay by substituting a new unit for the faulty one. The latter would be passed down the line to a technician, who would bring his more specialised skill to bear upon isolating the fault at sub-unit or component level—and, even here, special programmed routines would be used for the diagnosis. However, programmed routines offer other advantages in addition to time saving:

1. They enable the operator to play a more responsible role, for he does not merely inform the technician of a faulty apparatus, but clears the fault himself. As an added bonus, this sort of deeper participation can also improve the operator's morale.

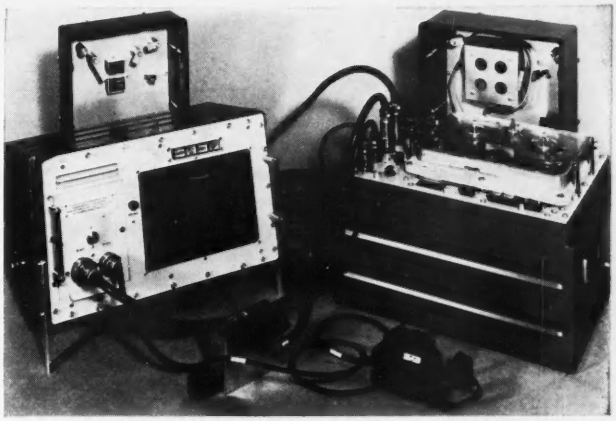
2. They release the technician from run-of-the-mill work, and enable his time and skills to be put to better use elsewhere.

Flow diagram of the basic audio programme





Left: Schematic diagram of the AVDA system.



Above: The AVDA equipment. The display unit is on the left, the tape unit on the right, and the remote control in the foreground.

A programmed routine, therefore, is a series of instructions which lead the user through a logical sequence of actions enabling a system to be tested and faults located and corrected. It also ensures that learning becomes an easy process, taking place at a level at which the user can cope. Programmed routines are used extensively in a wide range of disciplines. For instance, they form an integral part of operational programmes for systems monitoring, fault finding or training in the radar, electronics, weapons and mechanical-engineering fields, and they have also gained a foothold in medical diagnostics. The programme presentation may be visual and/or audible. Audible directives may be difficult to 'hold' for any length of time, and consequently are accompanied by pictorial detail (eg, charts, diagrams or waveforms) and instructions which can be 'held' for as long a period as required.

AVDA

The Royal Electrical and Mechanical Engineers, the Royal Radar Establishment and the Signals Research and Development Establishment have conducted many investigations and trials with prototypes incorporating the concepts outlined above. On the basis of this work, supplemented by its own research, Training Aids (Bristol) Ltd. has produced an Audio-Visual Diagnostic Aid using programmed routines, which has been given the name of AVDA. AVDA is a semi-automatic machine designed to present audio and filmed instructions to an operator working, for example, on equipment setting-up, testing and fault diagnosis, or instructional or educational projects. The equipment consists basically of a cassette-loaded semi-automatic magnetic-tape transport unit incorporating electronics enabling a complicated *yes/no* branching routine to be followed by the operator, and, since each step in the programme is given in detail in the form of an instruction and/or a question, the user need not be familiar with the procedure or project. A separate synchronised visual-display unit is provided for optional use, permitting audio-visual, or purely audio, programmes to be employed as required.

The operator controls the progress of the programmed information by pressing a *yes* or *no* button, as appropriate, in response to the audio/visual instructions and questions, and a repeat button is provided in case the user is distracted during the playing of an audio passage. The controls are duplicated at a remote-control station to give some freedom of movement to the operator. Audio information is presented either by head telephones or loudspeaker. The logic and control circuitry employs integrated circuits, and the system is mains-operated.

The audio programme

The audio programme consists of main routines and sub-routines. The main routine comprises a series of main messages, each of which may be succeeded by a sub-routine having a maximum of 99 sub-messages, which form the branching facilities on which the system depends. The main routine is adhered to by answering *yes* to each main message. A *no* reply initiates the sub-routine, and this route is then followed by answering *yes* or *no* to each sub-message until the last sub-message in that particular branch of the sub-routine is reached. This last sub-message is generally coded to provide a repeat of the previous main message, the reply to which should now be a *yes*. With this *yes* the operator continues to the next main message, and so on. The sequence is illustrated in the flow diagram on page iv.

AVDA usually has facilities enabling the operator to repeat any audio message or film frame, and an automatic search can be made for any main message in the sequence 1 to 999.

Increasing versatility

Training Aids (Bristol) Ltd.'s research into audio/visual peripherals for computer-aided teaching projects has recently resulted in the development of audio and visual random-access units, which, based on the proven techniques of AVDA, provide all the electronics and logics required to operate the AVDA magnetic-tape and film-strip equipment by computer, tape reader or other method of remote control. These developments have widened the scope of the apparatus considerably, and, in addition to its initial applications, it can now be used for medical and psychological diagnosis, for hospital patient monitoring and as a computer-controlled teaching aid. Without doubt, however, its fields of application will increase even further as industry, medicine and education become more aware of its potentialities.

More information:

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Industrial Applications Unit, Royal Radar Establishment, Procurement Executive, Ministry of Defence, St. Andrews Road, Great Malvern, Worcs WR14 3PS. Tel: Malvern 2733, ext. 2762.

SRS Quantifies Reliability
UKAEA's Systems Reliability Service

Sectors of industry operating potentially hazardous plant and equipment have obviously to evaluate their risks with some precision. Of importance to industry as a whole is the fact that the methods they have evolved for predicting reliability are equally applicable to any 'safe' process or system, and, so applied, can often lead to considerable savings in plant operational costs. In the nuclear-energy field, where Britain has considerable experience, the risks from uncontrolled radioactivity have been a matter of prime concern, and the social obligations pertaining to these risks have led to the development of a new discipline: reliability technology. The UK Atomic Energy Authority's experience and know-how in this field are embodied in its Systems Reliability Service.

Entailing the superimposition of probability calculations on any number of engineering variables, reliability prediction has been labelled the 'complete technology'. In addition to defining possible risks to human life from hazardous plant, it enables a fairly exact prediction to be made of the performance of individual parts, assemblies, and even complete systems, where the only costs of failure may be monetary. The required information can often be derived from examination and correlation of well-known data on the constituent parts, and overall reliability can be assessed by techniques combining engineering assessment, systems analysis, logistics and probability calculus. But before any calculations can be made of reliability or safety performance, this information on the likely performance of components, based on experience, has to be collated. Precise and documented knowledge of this sort has, however, not been available generally in industry, and the UKAEA's Systems Reliability Service therefore took a lead in establishing a data bank on the performance (particularly the failure characteristics) of components.

Using such information, the SRS is able to look at any item or plant and assess its reliability and safe risks—the risks, say, inherent in a continuous process or synchronised operation. Maximum productivity (the design performance) may be an impossibility economically, but, given definite economic constraints, reliability techniques can define the optimum scale and nature of stand-by components, safety controls and detection systems.

Reliability technology can also put the decision-making process in plant design on a strictly quantified and logical footing, so that reliability of operation is guaranteed without itself creating economic waste through unnecessary precautions. Firstly, it has to be known, often before the executive decision is taken to begin installation, whether the protective systems are adequate, and, if not, how they can best be made so. And, secondly, the system must not be 'too safe', so that false operation of the trip system leads to spurious shut-downs.

The SYREL data bank

SRS's evaluations are based on the years of experience with many sorts of component stored as information in SYREL—the Reliability Data Bank which SRS established in 1961. SYREL's data are derived from over 100 sources, including a number of reactors and other plant of the UKAEA itself. Hundreds of thousands of items of fault data on a large number of components common to several industries are now stored on the SYREL computer, ranging from pneumatic control valves (which operate on average for 4 years without trouble), to boiler feed pumps (some of which fail after only 6 weeks' operation), to transistorised amplifiers. For example, the total number of samples of data on valves now held in the bank is nearing 200, covering manual, motor-operated, solenoid-operated, cylinder-operated, mechanically-actuated and relief valves in the aircraft, chemical, nuclear, power-generation and general industries. This kind of collated information has not always been generally available in industry, and it is part of the SRS service, on a suitable repayment basis, to allow plant managers access to generic reliability information on frequency of breakdowns, outage times, repair times, etc. SYREL is beginning to assume a national role as a standard for data storage, the code being extremely detailed and comprehensive. Basically it is a mixture of alphabetic, numeric and alphanumeric digits, but it includes facilities for plain-language entries. Encoding and storing is undertaken by SYREL staff, and the special punched layout cards used are suitable equally for card input to computer storage, magnetic encoding direct on tape, or remote terminals direct to the computer. Any information contributed to the bank remains confidential to the contributor, but generic reliability information is distilled by the computer from all the sources.

Confidential project service

SYREL information is available to inquirers, but it is also the basis of SRS's main work—its confidential project service. Under this service, SRS will, at any time from the design stage onwards, evaluate a customer's plant and provide a quantitative assessment of its performance and reliability characteristics. During the first two years of its existence, the Service has undertaken 30 such major projects for industry, and has answered 100 minor calls on its services.

What's SRS to you?

Over the past 20 years or so the Health and Safety Branch of the UK Atomic Energy Authority has built up an unrivalled mass of information on the performance of a wide variety of equipment, including electronic, mechanical and pneumatic instruments, electrical and automation devices, and such plant components as pumps, motors, bearings and seals. Derived from safety and reliability assessments of nuclear reactors and chemical and other types of plant, and from detailed records of operating history, these data offer an obvious base on which the likely performance of a plant can be quantitatively forecast, optimum maintenance schedules can be planned, the economic effects of plant modifications can be determined, and so on. To exploit the data in this way, the UKAEA has perfected specialised statistical methods of evaluating the information; and to facilitate their application, it has established a large, ever-growing data bank, linked to an extensive computer installation for rapid processing. In short, the UKAEA has at its disposal a systems-reliability organisation, which, with a highly qualified and experienced staff, and with the necessary facilities (eg, data store, computers, facilities for fundamental research and analytical and mathematical modelling) all under one management, has carved for itself a leading position in its field. Realising that this organisation could contribute greatly to the efficiency, maintainability and safety of plant in industry in general, the UKAEA has set out to place its facilities and know-how at the service of any firm requiring them. All its experience and information are now available, if not for the asking, at least on a repayment basis, from its Systems Reliability Service.

The types of service which SRS offers are outlined in this article. **For more information, contact The Manager, Systems Reliability Service, UKAEA, Risley, Warrington, Lancs (Tel: Warrington 31244, ext 2126 or 3005).**

Projects on plant availability range from an investigation of an ICI high-integrity protective system, to evaluation of different water-cooling and roller-drive systems for Pilkingtons. Safety assessments have included work on a plant-emergency system for the Danish Atomic Energy Authority and on a chemical-emission monitoring and fire-alarm system.

SRS is also ready to produce a scheme for recording plant faults for statistical analysis, evaluating the data and preparing a plan for improvement and equipment optimisation.

Where hazards to human life are involved, SRS will undertake more detailed assessments, designed to predict when faults are likely to be fail-safe or not.

Charges for the confidential project service depend on the amount of work involved, and are estimated in advance where possible. But there are no charges for the initial consultation, and, if the customer agrees to contribute to the bank performance information on his own plant and components, and/or to become an associate member, the charges can be reduced.

Associate membership

For an annual fee, organisations and companies can become associate members of the SRS. Associateship entitles them to access to SYREL, a certain amount of free consultancy work by SRS, generic reports and quarterly reports. The Systems Reliability Service has been encouraged by the number of organisations which have already become associates: they include several overseas atomic energy commissions and the Commission of the EEC.

Quantitative safety assessment

How is a quantitative safety assessment made? Taking the chemical industry as an example, the SRS has shown that, if a typical plant is continually attended, the probability of someone's being killed is about 3.0×10^{-4} (1965 figures). There is a relationship between hazards due to a high-risk chemical plant and its protective system, equal to the probability of a safety demand at any given moment multiplied by the fractional dead time of the protective system. The demand rate would normally be low, perhaps caused by the failure of one of two pneumatic valves in a year. There might be the same failure rate in the control system, and a similar human error, giving a total demand of three a year. This leads to a system fractional dead time of 2.0×10^{-4}. To this mathematical evaluation are added engineering criteria: no single equipment fault shall prevent the correct operation of the protective system, should this be necessitated by a plant fault condition; no statistically significant combination of two faults should inhibit operation of the protective system; and each specific fault should be monitored by two different, independent methods of measurement.

In a chemical plant the relevant parameters might, for example, be the rates of flow of inert and reactive gases that make up a potentially explosive mixed gas stream, and it is important to measure the characteristics of the ratio-measuring devices. The slowest acting protective channel (gas analysis) is capable of shutting down a plant, so the response of the flow-ratio channel has to be adequate. If the two channels have fractional dead times of 1.8×10^{-2} and 5.3×10^{-3} and act independently in a one-out-of-two trip configuration, the combined fractional dead time becomes 1.3×10^{-4}, and 1.5×10^{-4} for the complete shut-down system of safety circuits and shut-down mechanism. This reliability therefore meets the stated needs of the plant of 2.0×10^{-4}.

To take an actual case study, in one large £6 million chemical plant, the manufacturers (ICI) worked for two years to design a high-integrity protective system using triplicated initiators with majority voting to provide a very high number of trip-initiating parameters, giving extraordinary safety without spurious shutdowns. When completed, it had 50 trip-initiators, all triplicated, six 'guard lines' of electrical voting equipment, duplicated shut-down systems, considerable protective devices and on-line testing facilities. It cost over £140,000. The SRS was called in to assess the system independently. Analysis of the actual initiator failures that took place when the system was complete showed that spurious trips resulting from two-out-of-three voting had been cut to about a twelfth of what they would have been with one-out-of-one trip initiators. The saving in outage was estimated by ICI to be of the order of £60,000 a year.

In another project, the SRS was called in by the Department of Trade and Industry to investigate the reliability of high-pressure die-casting machines. The aim was to evolve general reliability factors that would optimise design and operation, and data were collected from two factories. These revealed that in one factory the average availability of 37 machines was 60 per cent, and in the other the availability of 35 machines was 72 per cent. The principal cause of outage was found to be the tools and their associated systems, and, ignoring tool faults, the average availability of the basic machine systems would have been about 85 per cent. Among other things, the SRS concluded that some component parts were prone to failure because they were not adequately designed for their operational environment. There were few facilities for monitoring, and it was recommended that maintainability and ergonomics be improved. The actual rate of failure in the two factories was about double that predicted from theoretical calculation, but availabilities of 90 per cent appeared to be achievable without basic alteration of machine design.

Effluent and Water Advisory Committee

(*continued from page ii*)

The expertise available

Some indication of the immense amount of know-how which the Committee's member organisations have at their disposal can be gained from the list of processes and subjects given in the box on page ii. The list is meant to be illustrative only, and is by no means all-embracing. If you need guidance on any aspect of water usage and/or treatment and disposal of effluent, the odds are that the Effluent and Water Advisory Committee will be able to help you. And this help stretches in certain cases to the design of treatment plant and the undertaking of investigations on a contract basis, and even to representing a company in negotiations with a pollution-control authority.

For more information, or to use the Committee's services, contact: Mr. J. Ford, The Technical Secretary, The Effluent and Water Advisory Committee, Water Research Association, Ferry Lane, Medmenham, Marlow, Bucks SL7 2HD. Tel: Hambleden 282.

Holding Crumbling Frescoes together

(*continued from page iii*)

as a liquid, the space between the framework and the mural can be filled simply by using a domestic vacuum cleaner as a 'pump'. To prevent blockage and facilitate flow, RAE constructed a simple feeder device from cartons, as shown in Figure 3. The spheroids are poured into an upper carton, through a hole in which they then flow into a funnel leading to the vacuum cleaner; thence they are fed via the vacuum-cleaner pipe into the mural space, filling it as evenly as a liquid.

RAE has proved the efficiency and practicability of its technique in tests in the field. Figures 1 and 2 show the protective covering under and after construction. When the covering was eventually taken down (to remove the filling it was necessary only to slit the bottom panel of the fabric, and the spheroids drained out as smoothly as sand running in an hour glass), the painting was found to have been not only protected, but also made more attractive, since the filling appeared to have cleared the face of dust and cobwebs.

news

Modular graphics presentation by CAD Centre

DTI's Computer Aided Design Centre will be holding a Seminar to discuss and demonstrate its Modular Graphics System at the Institution of Electrical Engineers' headquarters, Savoy Place, London WC2, on September 19, 1972. Developed over the past three years, this system is based on the GINO concept (but with major additions). The software provides users with the means of writing interactive graphics programs at the FORTRAN level, utilising any terminal device from a plotter to a remote satellite computer-controlled display. It includes comprehensive drawing and picture-manipulating facilities, which may be selected in a modular fashion according to the task in hand and the terminal device in use. Those parts of the system not already in FORTRAN are being re-written, to permit their implementation on a variety of computers. The September seminar will be of interest to computer manufacturers, bureau operators and graphics users. The fee is £15, and applications should be made to The Chief Consultant, The Computer-Aided Design Centre, Madingley Road, Cambridge (Tel: 0223-63125).

Electronic-equipment design and manufacture

Dr. I. Maddock, Chief Scientist, Department of Trade and Industry, is to give the opening address at the Conference on *Electronic Equipment Design and Manufacture* to be held at the David Hume Tower, University of Edinburgh, from September 26 to 28, 1972. The conference is being promoted by the Scottish Centres of the IEE (E & C Section) and IERE, and co-sponsors include the I Mech. E, I Prod. E, IEETE and IEI. The papers to be presented will cover such subjects as automatic test equipment, computer-aided design, quality control, integrated circuits, reliability, hybrid technology, solderability, printed circuits, styling and marketing. The conference should appeal to design engineers, production engineers and graduates entering the electronics industry. More information: Mr. G. K. P. Ayrton, Post Office Telecommunications Headquarters, Canning House, 19 Canning Street, Edinburgh EH3 8TH.

Group technology

Compiled by the University of Birmingham's Centre for East European Studies, under a contract placed by the UKAEA's Group Technology Centre on behalf of the former Ministry of Technology, *Group Technology—A Comprehensive Bibliography* is now available (price £3.00) from Her Majesty's Stationery Office. The 171-page bibliography, which contains more than 800 references, will provide support for the Centre's continuing role of furthering the adoption of group-technology practices by industry. More information on the Centre can be obtained by contacting: The Group Technology Centre, United Kingdom Atomic Energy Authority, Blacknest, Brimpton, Reading RG7 4RS (Tel: Tadley 4111).

BRS information list

A new list of current Building Research Station publications, films and services, *Information 72*, is now available. In addition to a classified list of publications, as in *Information 71*, it includes details of the Building Research Advisory Service, seminars held at BRS, and information for developing countries. The classified list and the numerical list of Digests cover publications in print in December 1971. The classification corresponds broadly with professional groupings and with the main fields of interest in the construction industry. Available free of charge from the Publications Officer, Building Research Establishment, Garston, Watford WD2 7JR.

The Duke of Edinburgh visiting the REME stand at the Symposium on Terotechnology held at the Institution of Mechanical Engineers, London, in May. The Symposium was organised and co-sponsored by the Institutions of Plant and Mechanical Engineers (the other sponsor was the Department of Trade and Industry), and Prince Philip opened the Conference in his capacity as President of the Council of Engineering Institutions.

Terotechnology is officially defined as 'the technology of installation, commissioning, maintenance, replacement and removal of plant, machinery and equipment, of feedback of operating and design experience thereon, and of related subjects and practices'; unofficially, and possibly more elegantly, it has been defined as 'the overall optimisation of maintenance'. Whatever the definition, however, the fact is that vast sums are being wasted in this country on maintenance which could be avoided by better design and better management, and the terotechnologist's role is to achieve this better design and management by an interdisciplinary approach. In making these points in his opening address, Prince Philip congratulated the Department of Trade and Industry for stimulating action in this field. Succeeding speakers, led by Dr. I. Maddock, Chief Scientist at the DTI, dealt with the detailed implications of terotechnology. Examples of its successful application were described, and possible educational measures were outlined. Each paper induced lively discussion from the floor, and in fact a consensus could be detected, both among the speakers and the 300 delegates. There was, for instance, general agreement on the vital importance of the concept represented by terotechnology, and the following other main points also commanded wide support: (1) only management can optimise terotechnology by co-ordinating the efforts of all departments; (2) in particular, management must realise that reduction of maintenance and increased reliability begin with good design; (3) adequate service and user data must hence be fed back to the designer (and consequently adequate cost and performance records must be kept); (4) performance criteria have to be established for terotechnology, but management must ensure that they are expressed in terms of overall plant economics; (5) the status of the terotechnologist needs to be raised at all levels; (6) the terotechnologist has to have a knowledge of most aspects of engineering, and at the higher levels, therefore, all engineers should be familiarised with the subject, rather than having to rely on post-graduate terotechnology courses, which would have to cover too wide a field; and (7) there is a need for a continuing interdisciplinary exchange of information on terotechnology, which might well be organised on an inter-institution basis.

The proceedings of the Symposium will, it is hoped, be published in due course.

More information: Where possible, items in *New Technology* indicate the best sources of further information. Readers are advised also to seek information on matters relating to *New Technology* from the following DTI regional offices: Edinburgh, 031-225 1822; Cardiff 62131; Newcastle upon Tyne 27575; Manchester, 061-832 9111; Leeds 38232; Nottingham 46121; Birmingham, 021-643 8221; Bristol 21071; London and South East, 01-684 9781; Eastern, 01-828 4355. In Northern Ireland, information is given by the Dept. of Industrial and Forensic Science, Belfast 21722.

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